

Taxonomical Studies on the Genus *Medicago* in Egypt

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Abstract. Eighty-three characters are used as OTU's for numerical investigation within the genus *Medicago*. The three clustering methods produce four groupings at relatively high dissimilarity level. The results obtained disagree with Urban's classification, while they seem to agree with Grossheim's taxonomic revision of the genus and are in partial agreement with Heyn's classification.

Introduction and Taxonomic Treatment

The genus *Medicago* belongs to tribe Trifolieae, of the subfamily Papilionoideae. This tribe comprises a group of genera which are characterized by having stipules adnate to the petiole (free in *Parochetus*), trifoliolate leaves and small seeds with well developed radicles. Schulz [1] isolated the genera *Medicago*, *Trigonella*, *Melilotus* and *Pactorovskya* in a separate tribe Trigonelleae on the basis of the ovule morphology. This treatment has not been accepted by Meikle [2], Heyn [3, pp. 383-385] and Small [4]. Small [5, pp. 169-181] eliminated the genus *Parochetus* from the Trifolieae and subdivided the tribe into Trigonellinae with the genera *medicago*, *Pactorovskya*, *Trigonella* and *Melilotus*; and Trifolinae with *Trifolium* only.

The genus *Medicago* comprises about 55 species [4], distributed mainly in the Western and Central Asia and in the Mediterranean countries [4; 6-12]. In Egypt the genus is represented by 16 species [13] distributed mainly along the Nile Delta and the Mediterranean coastal land. Members of this genus are annual, biennial or perennial herbs, having difficulties in their identification and classification due to the variation in vegetative and pod characters and the occurrence of intermediate forms [9]. Urban [14] was the first to represent a comprehensive study of the whole genus (46 species) with successful delimitation of the species. He noticed the importance of the venation on the surface of the pod as the most conservative specific character. He divided the genus into two groups on the basis of the presence or absence of a lateral,

or submarginal vein on the pod surface. He further subdivided them into ten sections using selected pod characters. Grossheim [15] followed Urban's treatment but he divided the genus into four subgenera: Falcago, Spirocarpos, Orbicularia and Lupularia, whereas Heyn [9] divided section "Spirocarpos" into four subsections according to some pod characters. Table 1 summarizes all the three treatments and indicate the position of the species in Egypt in these classifications.

Materials and Methods

About 93 fresh specimens representing 16 *Medicago* species recorded in Egypt, were collected from different habitats, their locations are indicated on the map (from Rafah to Maktala along the Mediterranean coastal strip, Fig. 1). These were used as OTU's (Operational Taxonomic Units) and a total of 83 characters including vegetative, floral and palynological characters and the habitats of the sampling site were employed. All the characters were scored and given equal weighting. Description of the characters and their scores (states) are presented in Appendix I. The *Medicago* species recorded in Egypt are: *M. arabica*, *M. aschersoniana*, *M. coronata*, *M. granadensis*, *M. intertexta*, *M. laciniata*, *M. littoralis*, *M. lupulina*, *M. marina*, *M. minima*, *M. orbicularis*, *M. polymorpha*, *M. rigidula*, *M. sativa*, *M. truncatula* and *M. turbinata*.

Three computer programmes were used in this study. The first two, CHANDAT and DISIM, enabled the calculation of a dissimilarity matrix designed and written by Dr. R.M. Wadsworth in the Department of Botany, University of Reading, while the third, ASF4, which was used to calculate three phenograms: group average, furthest neighbor and nearest neighbor, was designed and written by Streinbrenner *et al.* [16].

Results and Discussion

The results obtained are summarized on Tables 2 and 3. Four groups resulting from the three clustering methods used, are distinguished mainly on the basis of their pod shape and spineness, seed shape and surface. In the group average (Fig. 2), group 1 is characterised by having a wide variety of pod shapes (discoid, spherical, ovoid or cylindrical) with spines or tubercles on its surface, while the seeds are oblong to reniform and with a smooth surface. Group 2 has lenticular unarmed pods and deltoid, verrucate seeds. Group 3 has discoid unarmed pods with deltoid to ovoid, smooth-surfaced seeds and group 4 has unarmed pods and ovoid, smooth-surfaced seeds. These results disagree with Urban's classification as he divided the whole genus into two groups using only one character (presence or absence of a lateral vein on the coil-surface of the pod). These results seem to agree with Grossheim's classification, as his four subgenera correspond to the four major groups obtained, except for *M. marina* which he included with the perennials (in Egypt it is an annual species).

Table 1. Comparative classification of the genus *Medicago*

Egyptian species included	Urban (1973) as sections	Grossheim (1945) as subgenera	Heyn (1963) as subsection of section Spirocarpos
<i>M. orbicularis</i>	<p>Medicago Pod flattened, with 0.5 to 1.5 coils. Fringed or not at dorsal and ventral suture. Radicle as long as cotyledons.</p> <p>Orbicularis Pod lenticular or discoid with 2-5 coils, usually spineless. Radicle as long as cotyledons.</p>	<p>Annuals. Pods subspherical or lenticular, spineless.</p>	
<i>M. lupulina</i>	<p>Lupularia Pod one-seeded nutlet, reniform or lenticular. Radicle, about 1/2 cot.</p>	<p>Annuals or biennials, pods one-seeded indehiscent nutlets,</p>	
<i>M. sativa</i>	<p>Falcago Pod linear, falcate or coiled with 2-3 opencenter coils. Radicle as long as cotyledons.</p>	<p>Perennials, pod straight, sickle-shaped or coiled, usually with an open center, spineless and rarely tubercled.</p>	
<i>M. marina</i>			
<i>M. granadensis</i> Willd.	<p>Intertexta Pod large aoid with 3-9 coils, spiny or rarely spineless. Radicle less than 1/2 the cotyledons.</p>		<p>Pods soft, ovoid or discoid, spiny. Coils loose, without lateral veins. Spines emerge diagonally, seeds dark red brown.</p>
<i>M. intertexta</i>			
	<p>Scutellate Pod pergamentaceous with 3-7 cup-shaped spineless coils. Radicle less than 1/2 the cotyledons.</p>		
	<p>Rotatae Pod cylindrical, flat or convex, with 3-6 coils, spiny or tubercled. Rad. 1/2 the cotyledons.</p>		<p>Pod pergamentaceous, spineless or with irreg. short spines, coils loose, with or without lateral veins, seeds yellow.</p>
<i>M. littoralis</i> Rohde	<p>Pachyspi- Pod cylindrical to short with 2-7 close</p>		<p>Pods cylindrical, spherical or</p>

Table I. (Cont.)

Egyptian species included	Urban (1973) as sections	Grossheim (1945) as subgenera	Heyn (1963) as subsection of section Spirocarpos
<i>M. rigidula</i>	reae	coils, spiny or tubercled. Radicle less than 1/2 the cotyledons.	ovoid, with close coils spiny and spine less, coils with lateral veins. Seeds yellow.
<i>M. truncatula</i> Gaertn.			
<i>M. turbinata</i>			
<i>M. arabica</i>	Euspiro-	Pod discoid or short cylindrical, with	
<i>M. polymorpha</i>	carpos	1.5-6 loose coils, spiny or tubercled. Radicle-cot. and rarely spineless.	
<i>M. aschersoniana</i> Urb.	Leptospi-	Pod short cylindrical or spherical with	Pod soft discoid or cylin. spiny or tubercled with grooved spines.
<i>M. coronata</i>	reae	3-6 loose spiny coils. Radicle less	Coils thin loose with distinct
<i>M. laciniata</i>		than 1/2 the cotyledons.	lateral veins, seeds yellow.
<i>M. minima</i>			

Table 2. Dissimilarities between the major groups of the taxa studied by using CHANDAT & DISTIM

Group number	Related group no.	Dissimilarity		
		group average	nearest neighbor	furthest neighbor
1	2	57	53	●
1,2	3	66	62	68
1,2,3	4	75	75	75

● - not completely discriminated

Table 3. Taxa included in the subgroups of group 1 by using ASF4

Subgroup	Taxa		
	group average	nearest neighbor	furthest neighbor
a	<i>M. granadensis</i>	<i>M. granadensis</i>	<i>M. granadensis</i>
	<i>M. intertexta</i>	<i>M. intertexta</i>	<i>M. intertexta</i>
b	<i>M. turbinata</i>	<i>M. arabica</i>	<i>M. turbinata</i>
c	<i>M. arabica</i>	<i>M. marina</i>	<i>M. arabica</i>
d	<i>M. marina</i>	<i>M. coronata</i>	<i>M. polymorpha</i>
		<i>M. littoralis</i>	
		<i>M. minima</i>	
		<i>M. rigidula</i>	
		<i>M. truncatula</i>	
		<i>M. turbinata</i>	
e	<i>M. littoralis</i>	<i>M. aschersoniana</i>	<i>M. marina</i>
	<i>M. rigidula</i>	<i>M. laciniata</i>	
	<i>M. truncatula</i>	<i>M. polymorpha</i>	
f	<i>M. aschersoniana</i>		<i>M. aschersoniana</i>
	<i>M. coronata</i>		<i>M. coronata</i>
	<i>M. laciniata</i>		<i>M. laciniata</i>
	<i>M. minima</i>		<i>M. minima</i>
	<i>M. polymorpha</i>		<i>M. littoralis</i>
		<i>M. rigidula</i>	
		<i>M. truncatula</i>	

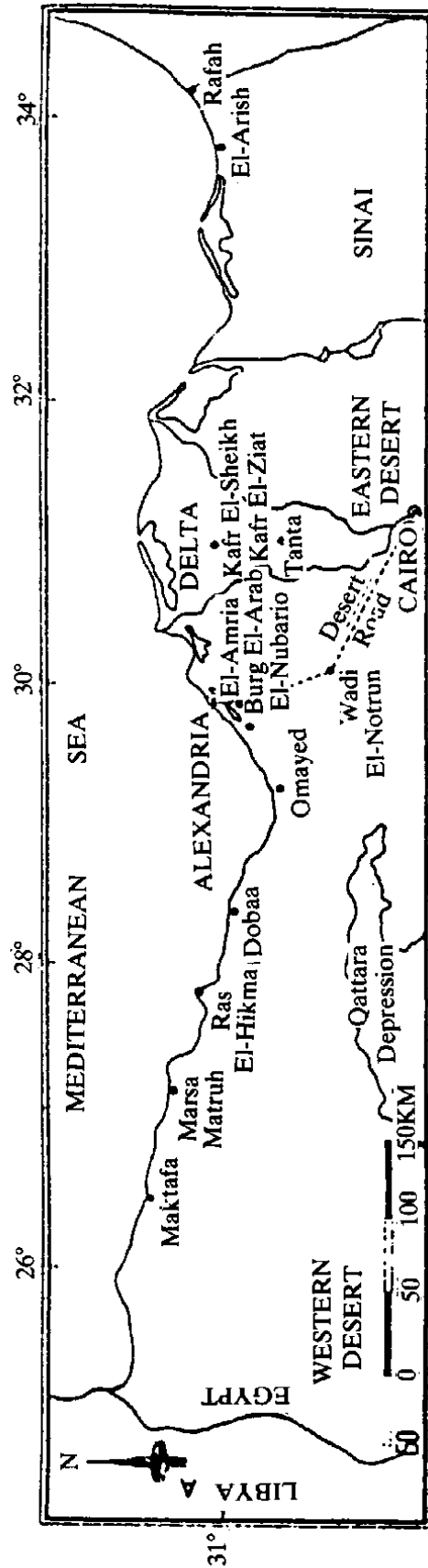


Fig. 1: Map of the Mediterranean coastal land of Egypt indicating the locations of the sampling sites (*).

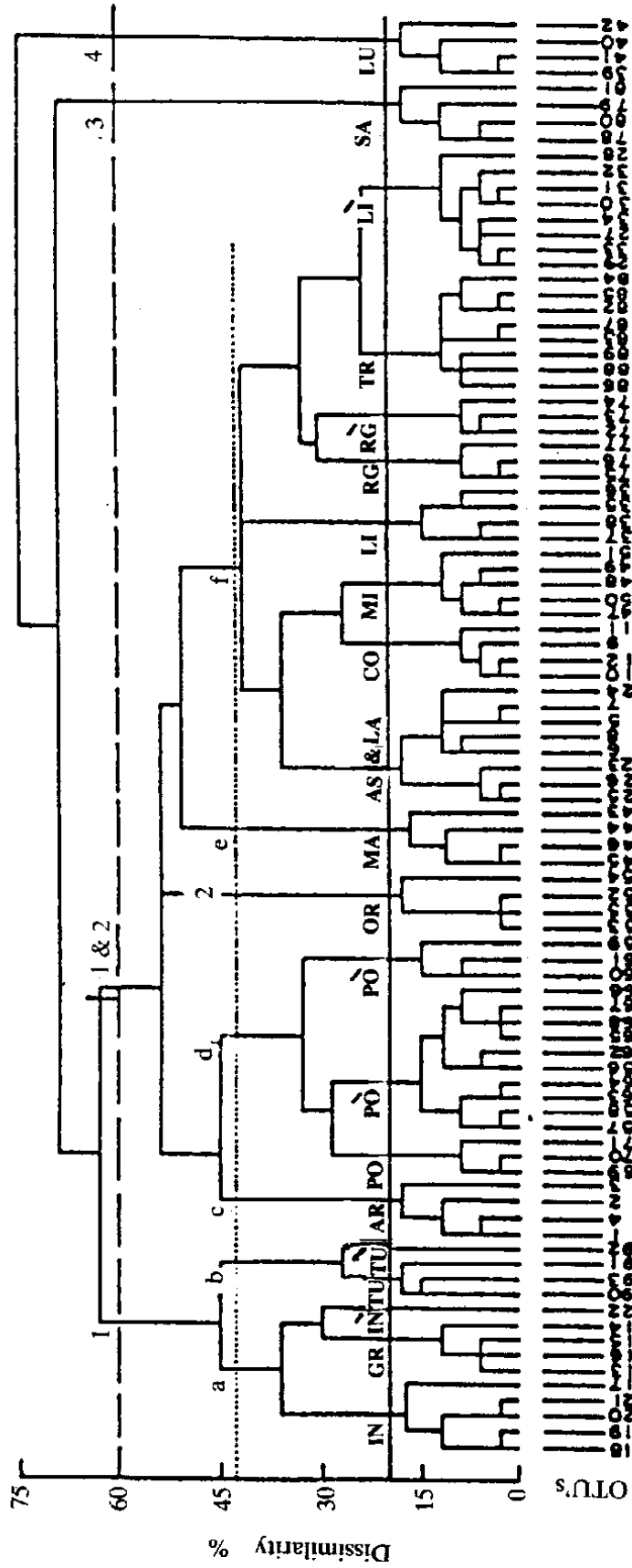


Fig. 2. Group average.

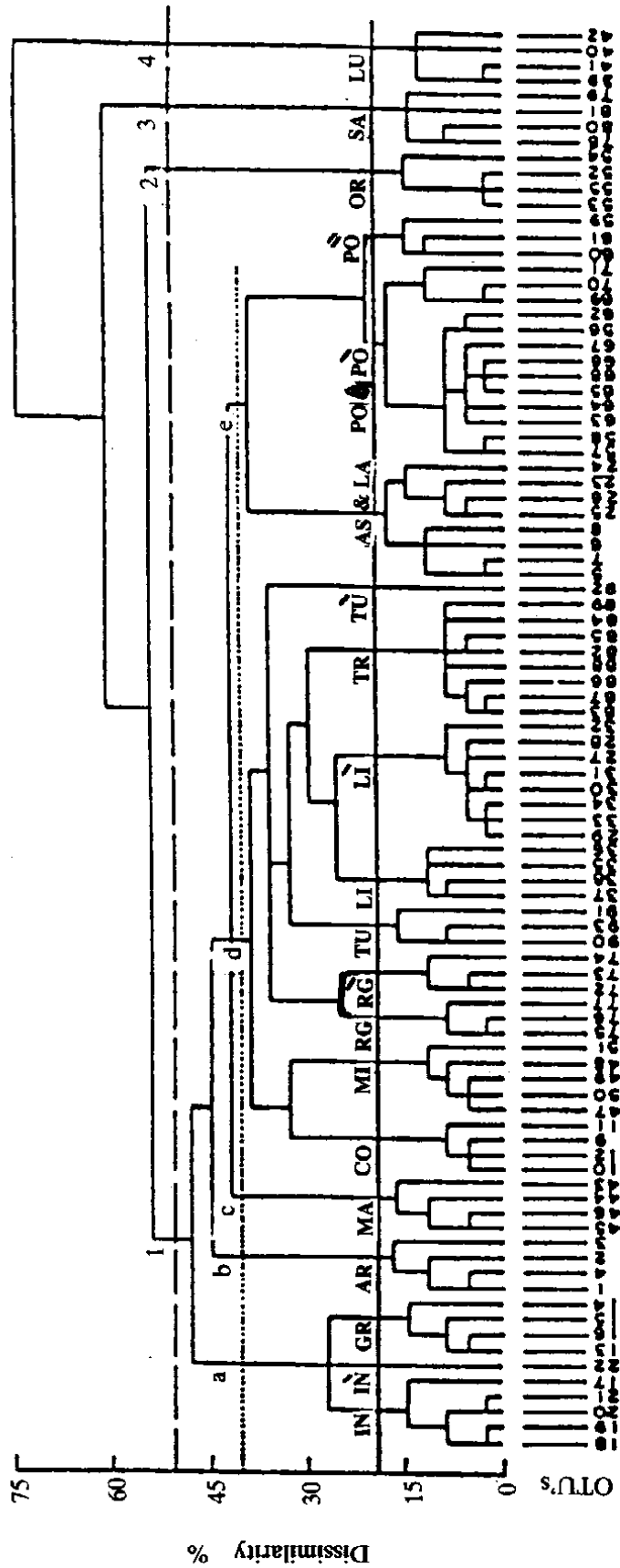


Fig. 3. Nearst neig.

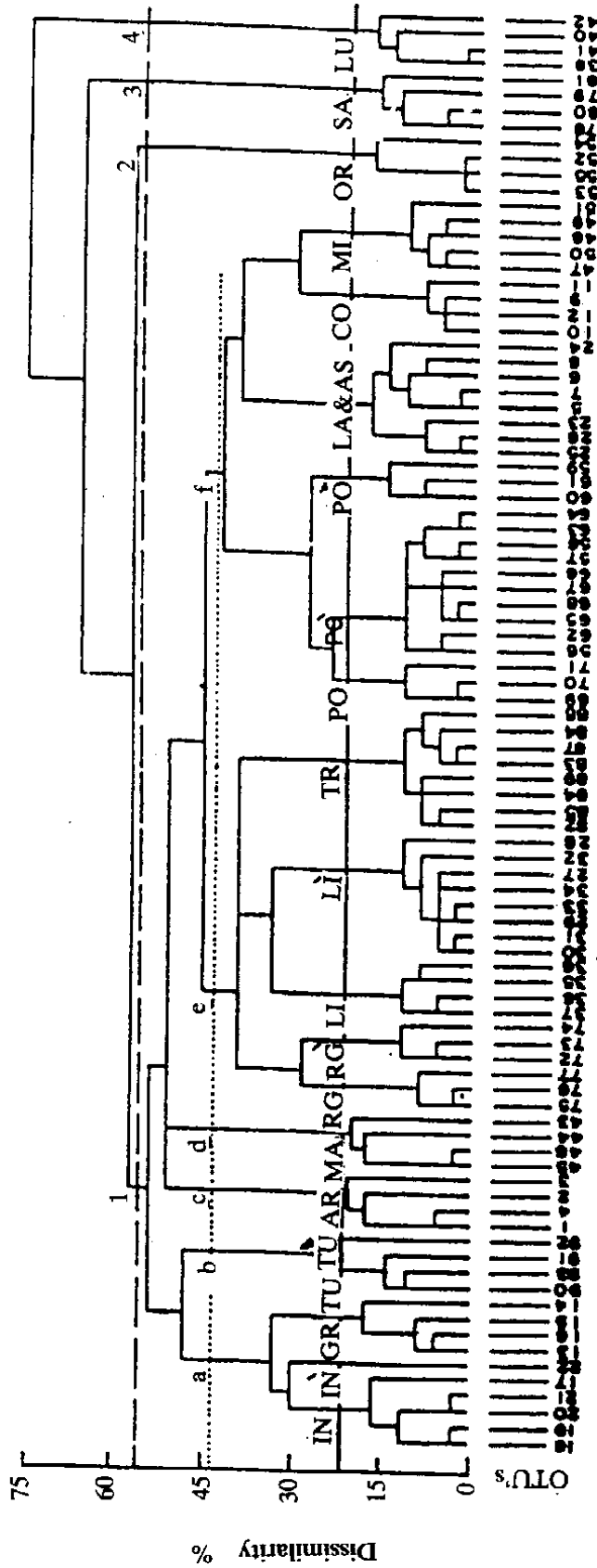


Fig. 4. Furthest neig.

Small *et al.* [17] expressed the view that except for perenniality, *M. marina* is strikingly like the species of section Spirocarpos, and this is in accordance with our results. *M. lupulina* is the most dissimilar of all the species and is considered as monotypic (Group 4). It, includes both annual and biennial forms, is covered by both multicellular glandular and multicellular simple hairs and its leaflet surfaces are nearly without or covered with traces of wax deposits. This is in agreement with Ingham's [18] findings who reported that *M. lupulina* was significantly different from other *Medicago* species in its phytoalexin response. Thus, it may be speculated that *M. lupulina* is a very distinctive species and is only distantly related to the other *Medicago* species. *M. orbicularis* which belongs to Group 2, has great affinity to the rest of the *Medicago* species, [17-19] and it is more appropriate to place it in a group by itself as was suggested by Grossheim [15]. *M. sativa* which represents the subgenus Falcago in Egypt forms a group of its own, Group 3. Group 1 representing section Spirocarpos in Egypt can be further divided into six subgroups (see Table 3). Taxa included in these subgroups differ, to a limited extent, depending on the clustering method (Figs 2-4). However, the results obtained from the average-linkage method seem to be more reliable.

These results suggest the delimitation of *M. arabica*, *M. marina* and *M. turbinata* as separate subgroup; *M. granadensis* and *M. intertexta* in another subgroup; *M. aschersoniana*, *M. coronata*, *M. laciniata*, *M. minima* and *M. polymorpha* as a third subgroup and *M. littoralis*, *M. rigidula* and *M. truncatula* as a distinct fourth subgroup. These results are in partial agreement with Heyn's classification [9]. Further the delimitation of *M. arabica* in a separate subgroup based on leaf morphological characters is supported by Simon's [20] findings who has reported its protein composition to be serologically different from the remaining *Medicago* species. Although *M. turbinata* has clear affinities with *M. littoralis*, *M. rigidula* and *M. truncatula*, it has been separated in a group of its own by the numerical treatment employed. This may be due to the fact that in numerical analysis technique all characters are given equal weightings which may alter the results. Also, the splitting of the same species in the dendrograms obtained is due to the variation in the habitats of the collected taxa. Accordingly, the results obtained are in accordance with Grossheim's and Heyn's classifications but disagree with Urban's.

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APPENDIX

Characters employed in numerical analysis and their scores

- 1- longivity (M.O.): 1-annual 2-annual and biennial 3-perennial.
- 2- Habit (M.O.): 1-procumbent 2-decumbent 3-ascending 4-erect.
- 3- Stem length (C).
- 4- Stem hairiness (M.O): 1-glabrous 2-sparsely hairy 3-moderately hairy 4-densely hairy 5-woolly canescent.
- 5- Stipule shape (M.U): 1-rounded ovate 2-ovate 3-lanceolate 4-acuminate.
- 6- Stipule margin (M.U): 1-entire 2-minutely denticulate 3-deeply dentate 4-laciniate.
- 7- Stipule length (C).
- 8- Petiole length (C).
- 9- Leaflet shape (M.U): 1-oblong 2-oblanceolate 3-narrow-obovate 4-broad-obovate 5-rhomboid-ovate 6-obcordate.
- 10- Presence of leaflet blotch (B): 1-absent 2-present.
- 11- Leaflet margin (M.O): 1-finely serrate 2-denticulate 3-dentate 4-deeply dentate 5-laciniate.
- 12- Leaflet apex (M.O): 1-obtuse 2-mucronate 3-rounded 4-trunculate 5-retuse-apiculate 6-emarginate.
- 13- Leaflet length (C).
- 14- Leaflet width (C).
- 15- Leaflet hairiness (M.O): 1-sparsely hairy 2-moderately hairy 3-densely hairy 4-woolly canescent.

- 16- Presence of glandular hairs on the leaflet (B): 1-present with low density 2-present with high density.
- 17- Presence of wax deposits on the leaflet (B): 1-absent 2-present.
- 18- Presence of multicellular glandular hairs on the stem (B): 1-absent 2-present.
- 19- Presence of multicellular pointed hairs on the stem (B): 1-absent 2-present.
- 20- Number of flowers per inflorescence (C).
- 21- Peduncle length (C).
- 22- Ratio between the peduncle and its subtending petiole (M.O): 1-shorter 2-equal 3-longer.
- 23- Color of the flowers (B): 1-yellow 2-purple.
- 24- Length of the pedicel (C).
- 25- Length of the flower (C).
- 26- Shape of the calyx teeth (B): 1-subulate 2-lanceolate.
- 27- Ratio between calyx teeth and tube (M.O): 1-shorter 2-equal 3-longer.
- 28- Length of calyx (C).
- 29- Hairiness of the calyx (M.O): 1-sparsely hairy 2-moderately hairy 3-densely hairy 4-woolly canescent.
- 30- Shape of the standard petal (M.O): 1-oblong-obovate 2-narrow-obovate 3-broadly-obovate 4-suborbicular.
- 31- Apex of the standard petal (M.O): 1-obtuse 2-retuse 3-emarginate.
- 32- Length of the standard petal (C).
- 33- Length of the wing petal (C).
- 34- Apex of the wing petal (B): 1-obtuse 2-rounded.
- 35- Ratio between lamina and claw of the wing petal (M.O): 1-shorter 2-equal 3-longer.
- 36- Length of the kel petal (C).
- 37- Ratio between the keel and the wing petal (M.O): 1-shorter 2-equal 3-longer.
- 38- Type of the staminal column (B): 1-with short free part of the filaments 2-with long free part of the filaments.
- 39- Shape of the ovary (M.O): 1-linear-oblong 2-elliptical-oblong 3-ovoid.
- 40- Hairiness of the ovary (M.O): 1-sparsely hairy 2-moderately hairy 3-densely hairy.
- 41- Presence of knee-like structure at the style base (B): 1-absent 2-present.
- 42- Shape of the pod (M.U): 1-reniform 2-lenticular 3-discoid 4-ovoid 5-spherical 6-short-cylindrical 7-long-cylindrical.
- 43- Color of the ripened pod (M.O): 1-yellowish-brown 2-brown 3-blackish-purple 4-black.
- 44- Number of the coils per pod (C).
- 45- Coil adpression (M.O): 1-loosely coiled 2-slightly adpressed 3-strongly adpressed 4-completely adpressed.
- 46- Diameter of the broadest coil (C).
- 47- Height of the pod (C).
- 48- Hairiness of the pod (M.O): 1-glabrous 2-sparsely hairy 3-moderately hairy 4-densely hairy 5-woolly canescent.
- 49- Presence of multicellular hairs on the pod (B): 1-absent 2-present.
- 50- Presence of few-celled glandular hairs on the pod (B): 1-absent 2-present.
- 51- Presence of spines on the pod (B): 1-absent 2-present.
- 52- Presence of tubercles on the pod (B): 1-absent 2-present.
- 53- Length of spines (C).
- 54- Number of spines in each row (C).
- 55- Insertion angle of the spines in a single pod (M.O): 1-90° 2-90°-120° 3-90°-140° 4-90°-180° 5-180°.
- 56- Shape of the spine (M.O): 1-ungrooved 2-grooved up to 1/2 length 3-grooved to the apex.
- 57- Curvature of the spine (M.O): 1-uncurved 2-slightly curved 3-strongly curved.
- 58- Apex of the spine (M.O): 1-straight 2-slightly hooked 3-strongly hooked.

- 59- Degree of hardening of the spine at maturity (M.O): 1-very soft 2-soft 3-hard 4-very hard.
 60- Number of the radial veins on the coil face (C).
 61- Curvature of the radial veins (M.O): 1-straight 2-curved 3-strongly curved.
 62- Mode of branching on the radial veins (M.O): 1-branched from the base 2-branched at the outer half of the coil face 3-branched at the outer third of the coil face 4-unbranched.
 63- Prominence of the radial veins (M.O): 1-poorly defined 2-distinct 3-prominent.
 64- Termination of the radial veins (M.O): 1-terminate at the dorsal suture 2-terminate at the base of the spine 3-terminate at the veinless submarginal zone 4-terminate at the submarginal vein.
 65- Presence of depression between the submarginal vein and the dorsal suture (M.U): 1-submarginal vein absent 2-submarginal vein present, depression absent 3-depression present.
 66- Number of seeds per pod (C).
 67- Seed shape (M.U): 1-deltoid 2-ovoid 3-deltoid to ovoid 4-oblong reniform 5-reniform.
 68- Seed length (C).
 69- Seed color (M.O): 1-yellowish-brown 2-reddish-brown 3-brown 4-brownish-black.
 70- Seed surface (B): 1-smooth 2-verrucate.
 71- Seed ornamentation (M.U): 1-wrinkled-undulate 2-papillate 3-reticulate.
 72- Mean polar length of the prolate pollen grains (C).
 73- Mean equatorial length of the prolate pollen grains (C).
 74- Ratio between polar and equatorial lengths (C).
 75- Presence of both tetracolporate and hexacolporate grains (M.O): 1-absent 2-present in low frequency 3-present in high frequency.
 76- Mean of colpus length (C).
 77- Mean of mesocolpi diameter (C).
 78- Type of endoaperture pore (B): 1-lolongate 2-lalongate.
 79- Presence of plug on the endoaperture pore (B): 1-absent 2-present.
 80- Exine sculpturing pattern (M.O): 1-finely rugulate 2-coarsely rugulate 3-perforate 4-granulate 5-nearly microreticulate 6-reticulate.
 81- Presence of sculpturing in the apocolpi (M.O): 1-absent 2-poorly defined 3-well defined.
 82- Presence of sculpture along the colpus margins (M.O): 1-absent 2-poorly defined 3-well defined.
 83- Habitat of the sampling site (M.U).

* Where the spines are absent the score 0 is given to characters 53-59.

* Binary character + B; multistate ordered characters = M.O; multistate unordered characters = M.U; continuous characters = C.

دراسة تصنيفية في جنس *Medicago L.* في مصر

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(سُلِّمَ في ٢٩ شعبان ١٤١٣هـ، وقُبِلَ للنشر في ٢٩ شعبان ١٤١٤هـ)

ملخص البحث. لقد تمّت دراسة ٨٣ صفة مورفولوجية واستخدمت للتحليل العددي لجنس *Medicago L.* المتواجد بالفلورا المصرية. ومن خلال التحليلات الثلاثة المختلفة تم فصل أربع مجاميع. وهذه النتيجة تبدو أنها لا تتفق مع تقسيم أوربان بينما تتفق مع دراسة ومراجعة جروسهين لهذا الجنس، كما أنها تتفق مع تقسيم هين.